Variability of Global Radiation Budget

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SSAI

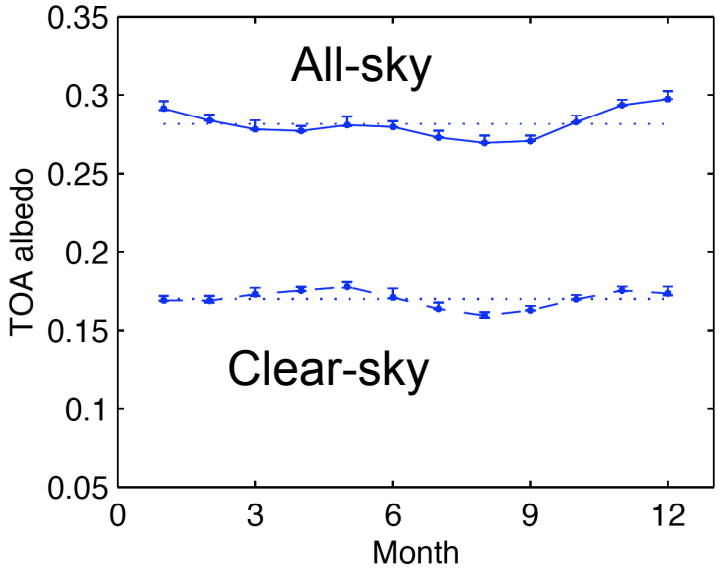
TOA Radiation variability

CERES data taken from March 2000 through February 2004 indicate that:

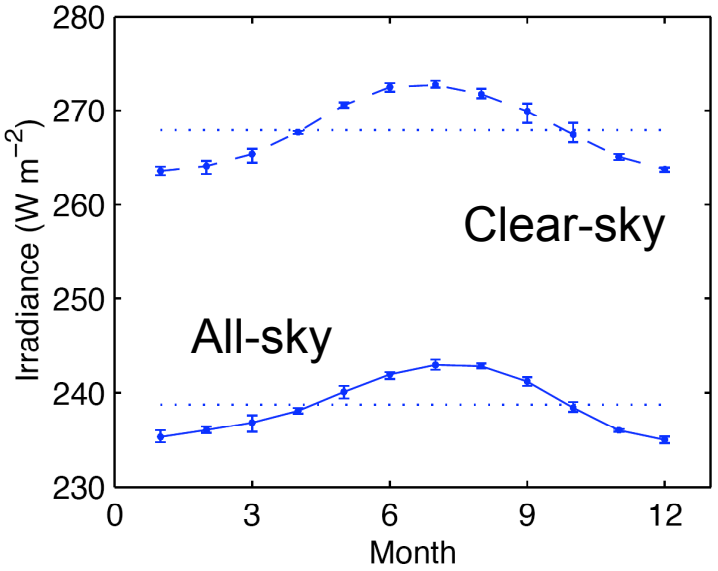
- Annual and global mean reflected shortwave is 97 W m^{-2} with the max. and min values of 97.2 W m^{-2} and 96.8 W m^{-2}. The difference of max. and min. values is only 0.4% of the mean.
- Annual and global mean OLR is 239 W m^{-2} and the difference of the max. and min. values is only 0.1% of the mean value.

Global Monthly mean Albedo and Longwave at TOA

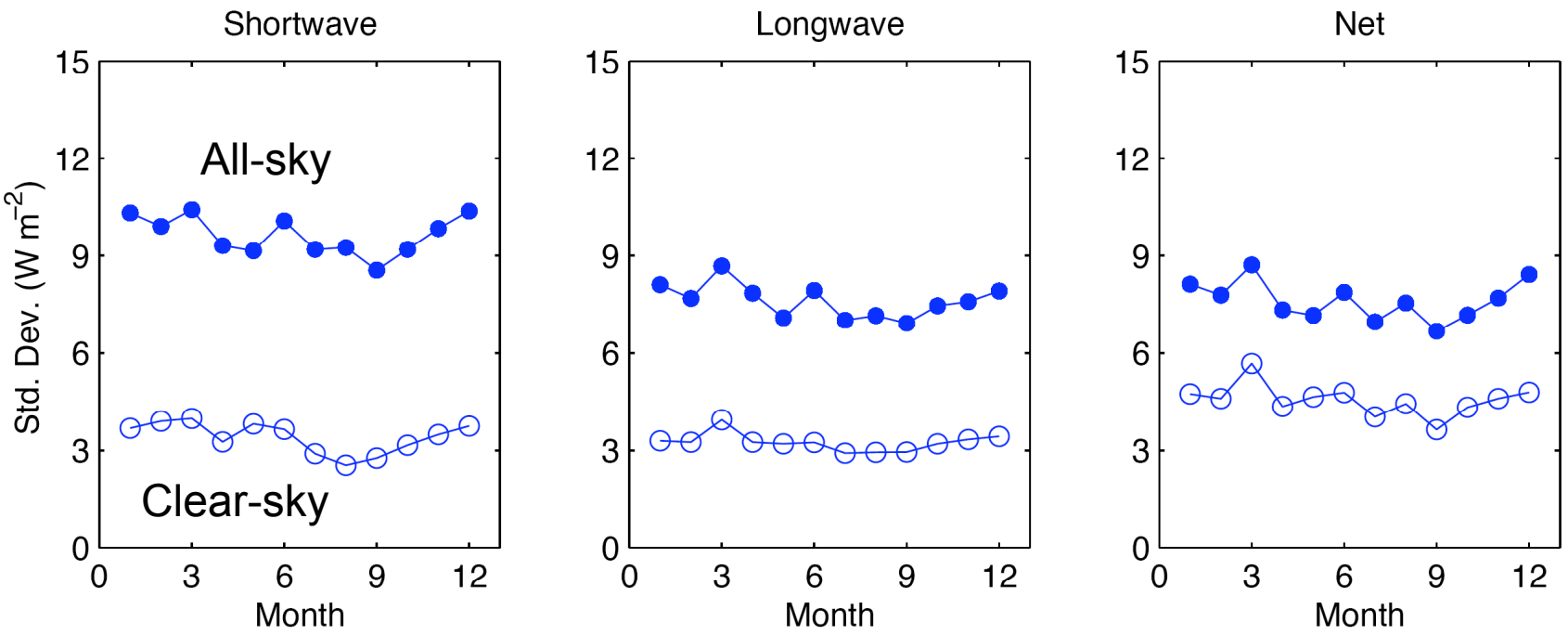
Albedo



Longwave



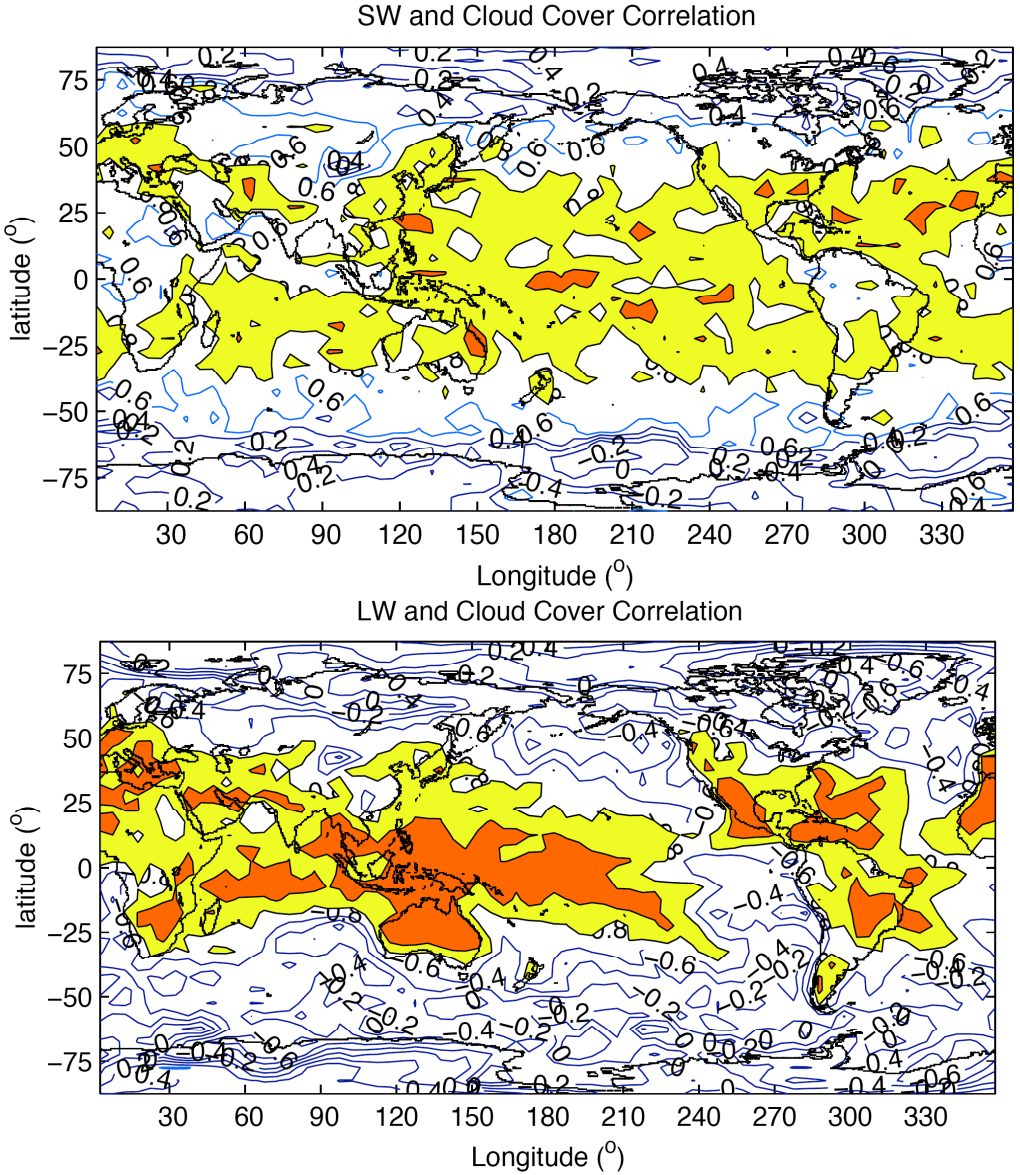
Standard Deviation of monthly anomalies



Standard Deviation of monthly 1ºx1º averaged over glove

$$\frac{1}{M}\left[\frac{1}{N}\sum_{N}(F-\overline{F})^2\right]^{1/2}$$

Cloud cover and TOA SW, LW Correlations



Colored area
Cf > 0.8

Colored area
Cf < -0.8

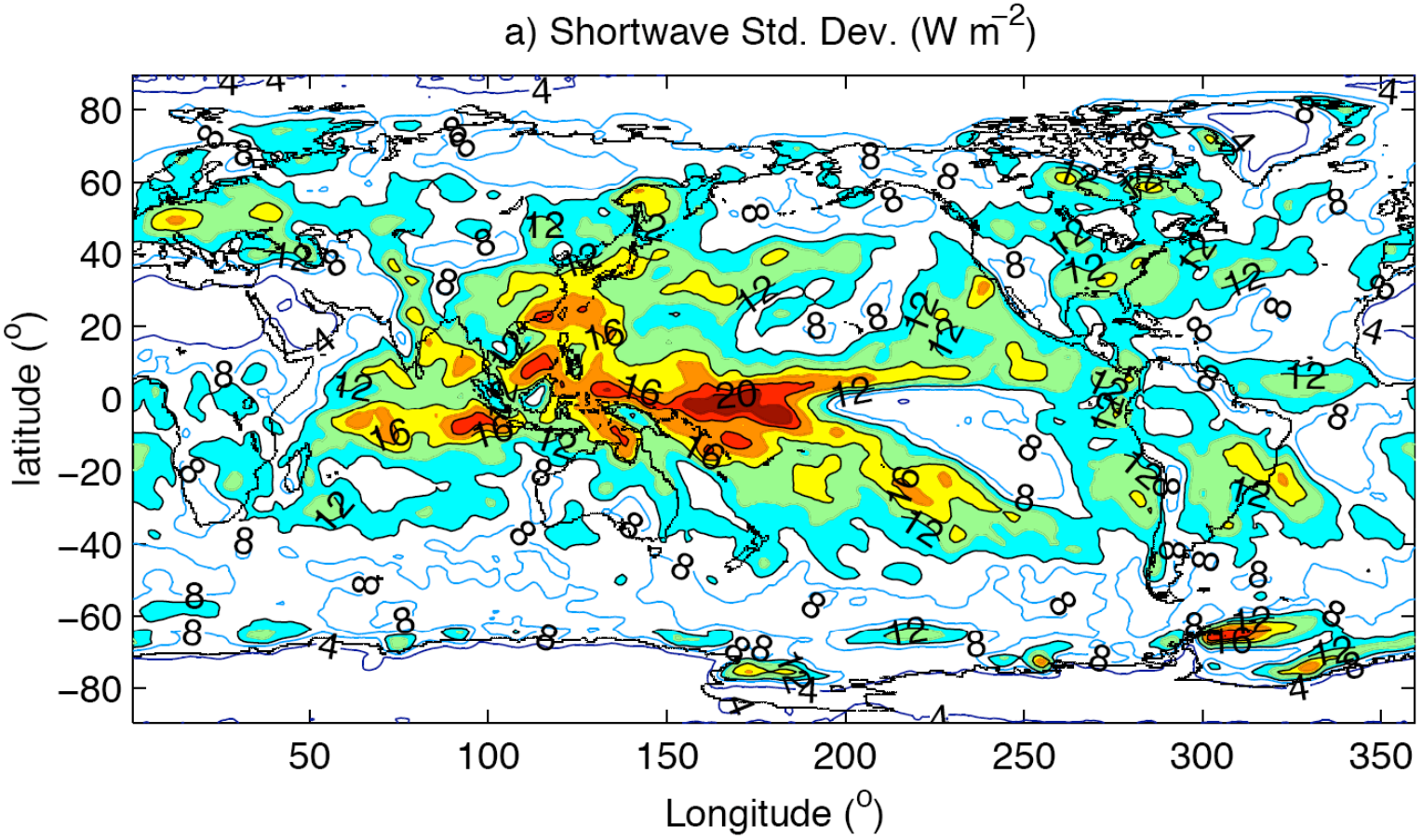
Clouds

- The global annual mean cloud fraction is 0.61 and the difference of max. and min. values is 0.003, which is only 0.5% of the mean.

Questions

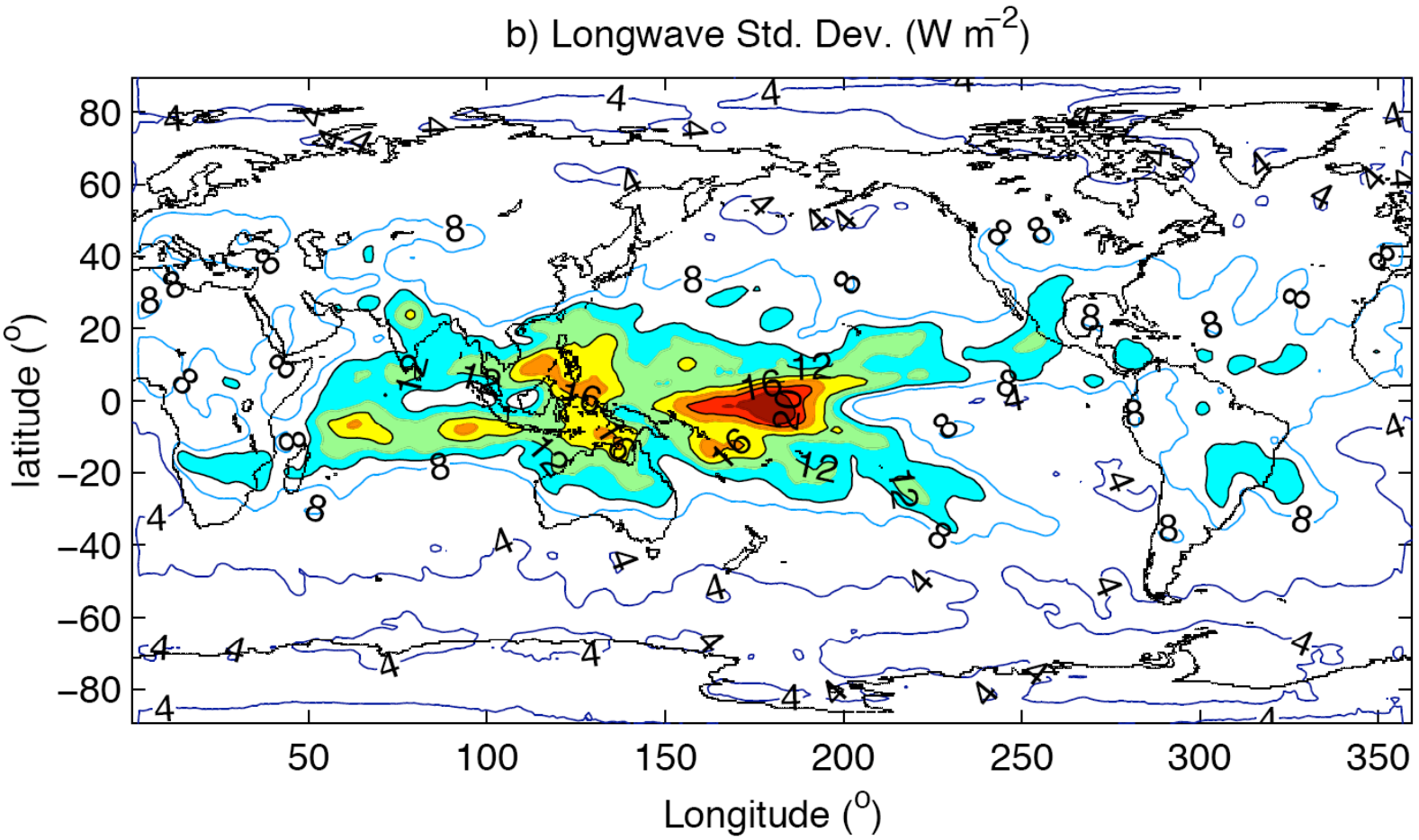
- Where do larger variations occur?
- Why are variabilities of SW and LW so small?

Standard deviation of SW Monthly Anomalies



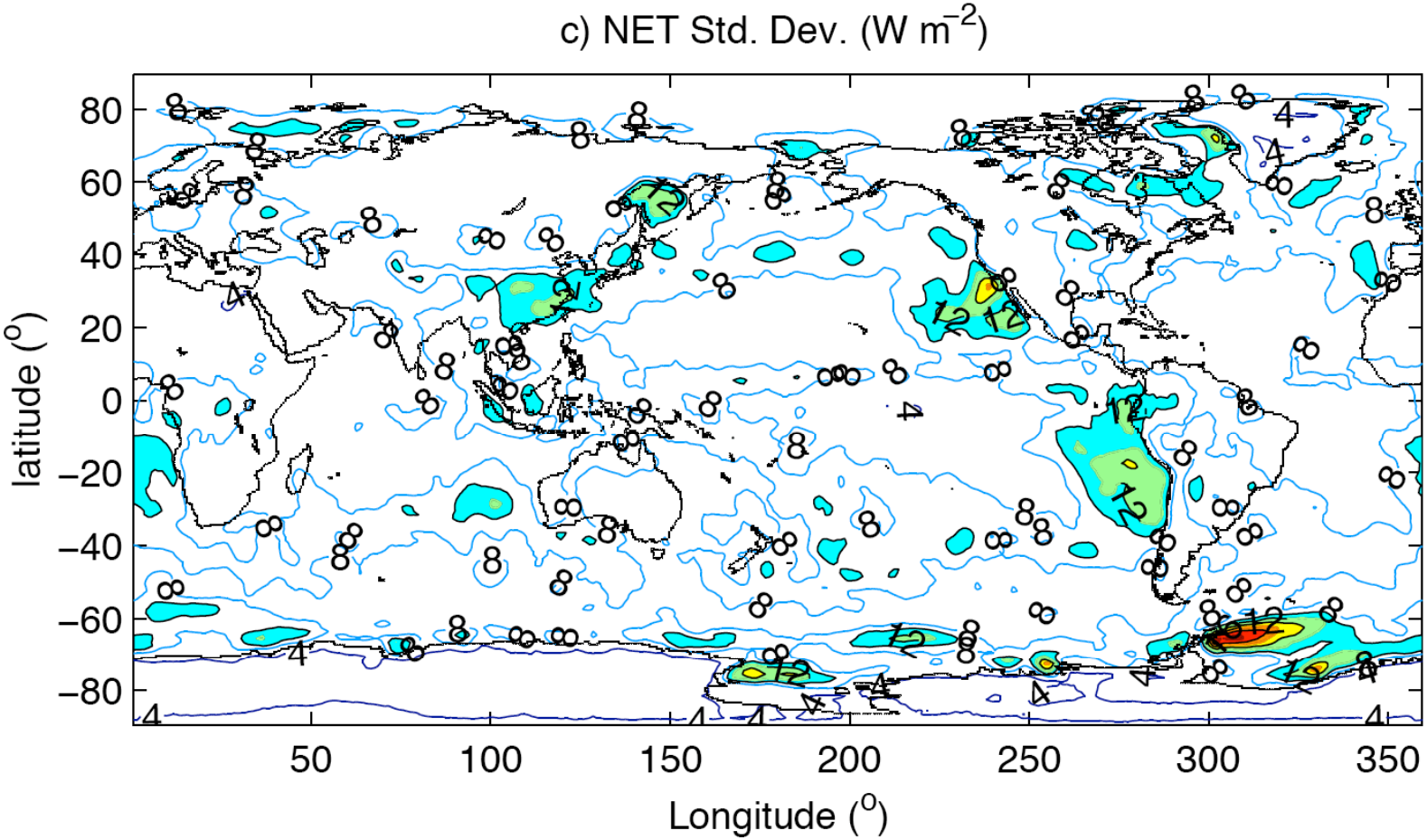
Colored area > 10Wm^{-2}, increment 2Wm^{-2}

Standard Deviation of LW Monthly Anomalies



Colored area > 10Wm$^{-2,}$ increment 2Wm^{-2}

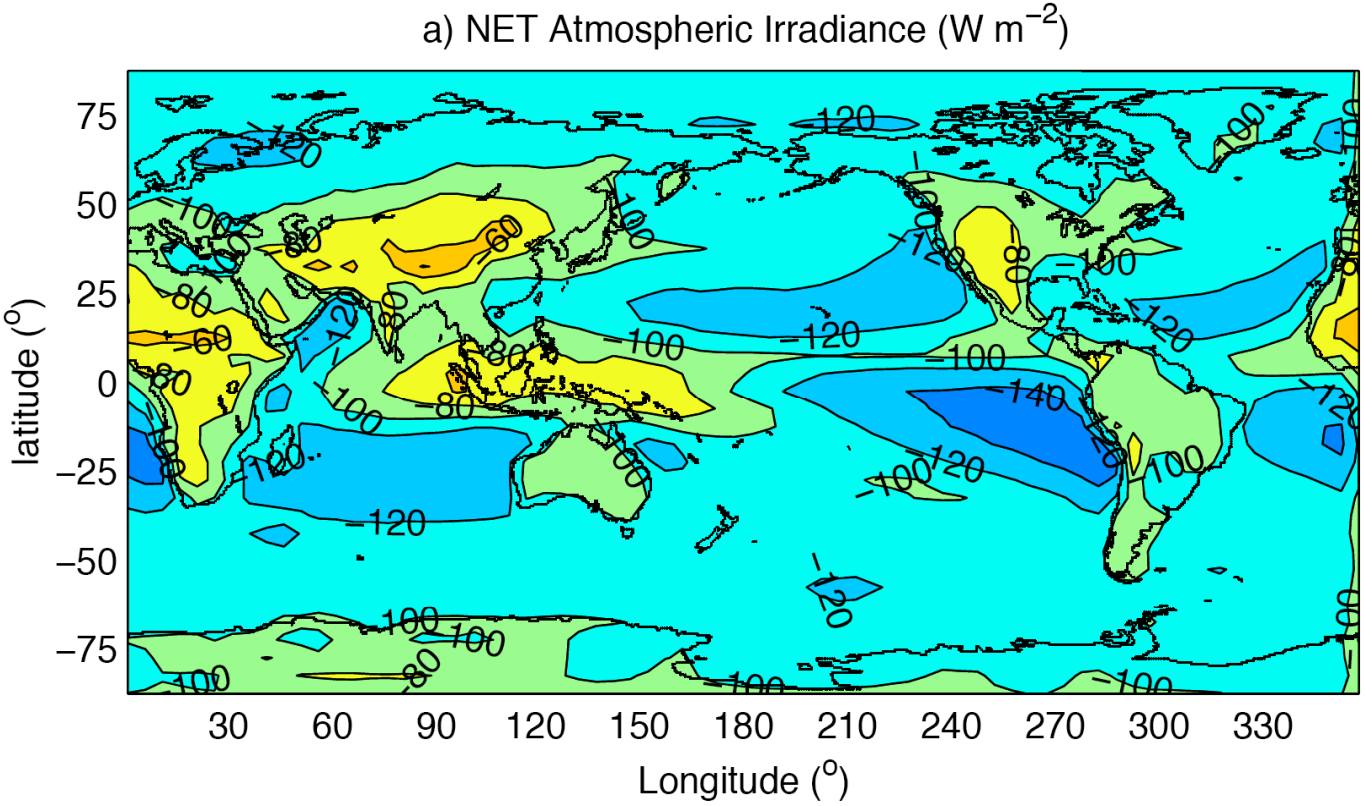
Standard Deviation of TOA Net Monthly Anomalies



Colored area > 10Wm^{-2}, increment 2Wm^{-2}

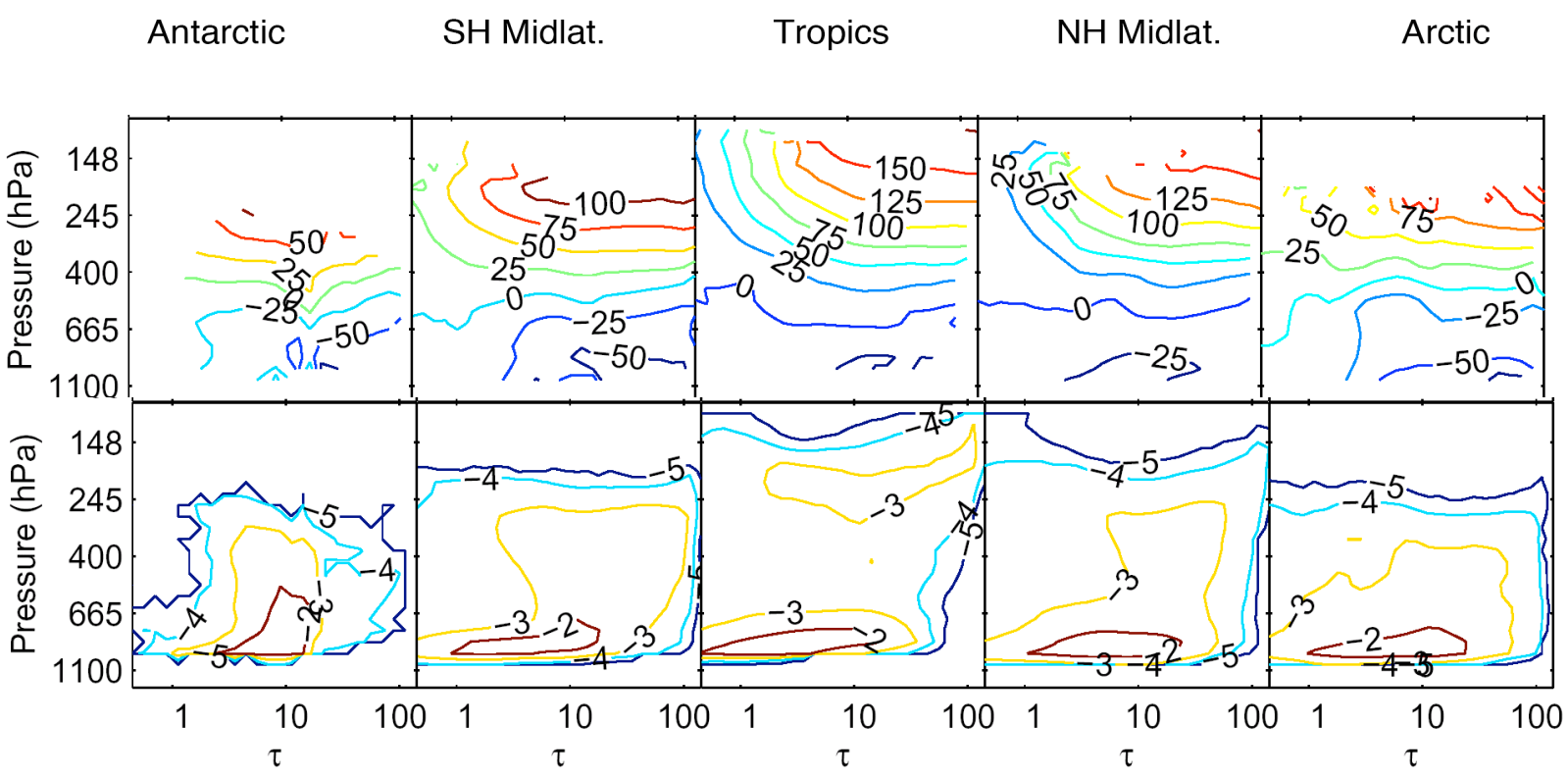
Why the variability is so small?

Atmospheric Net irradiance

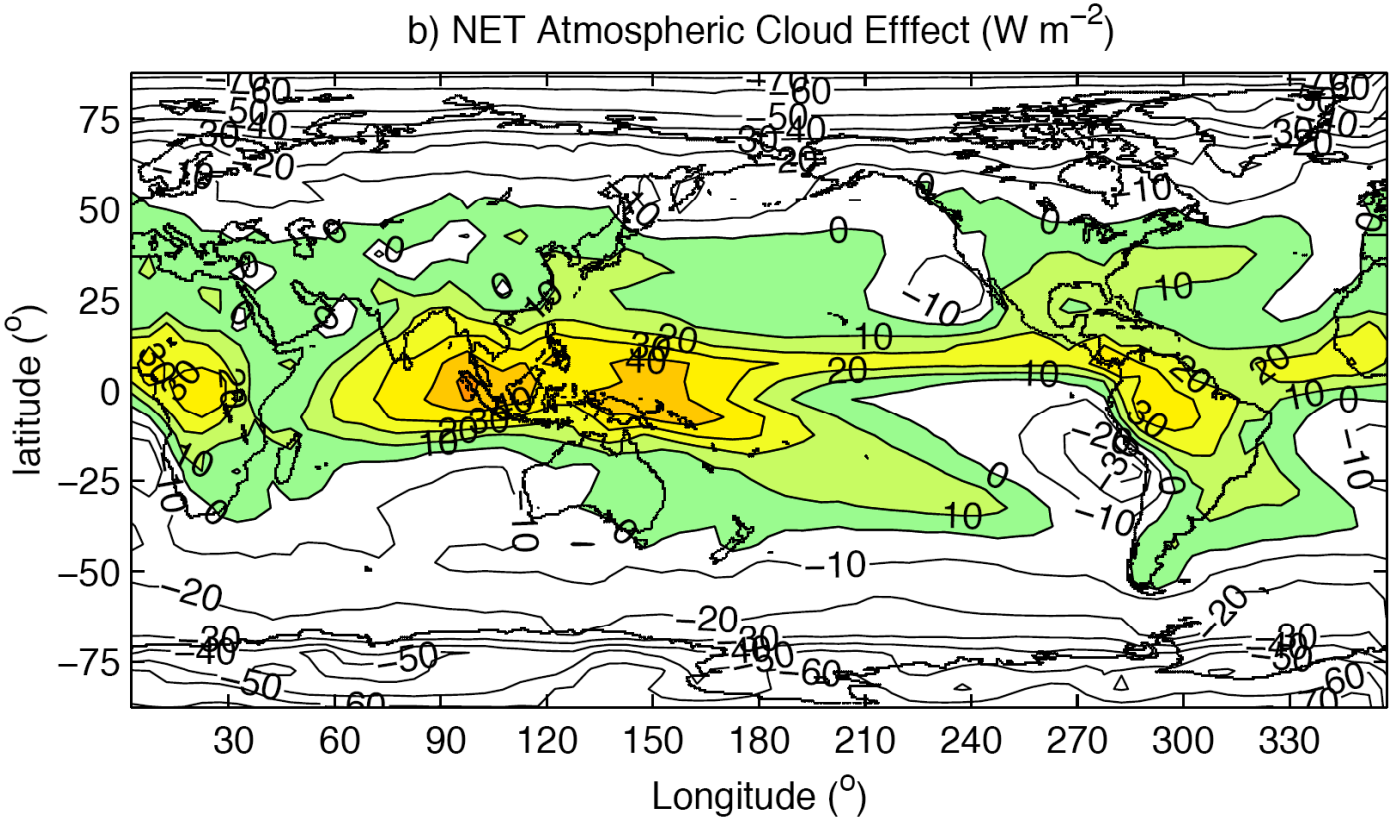


TOA net (SW+LW) - surface net (SW+LW)

Atmospheric net Cloud Effect

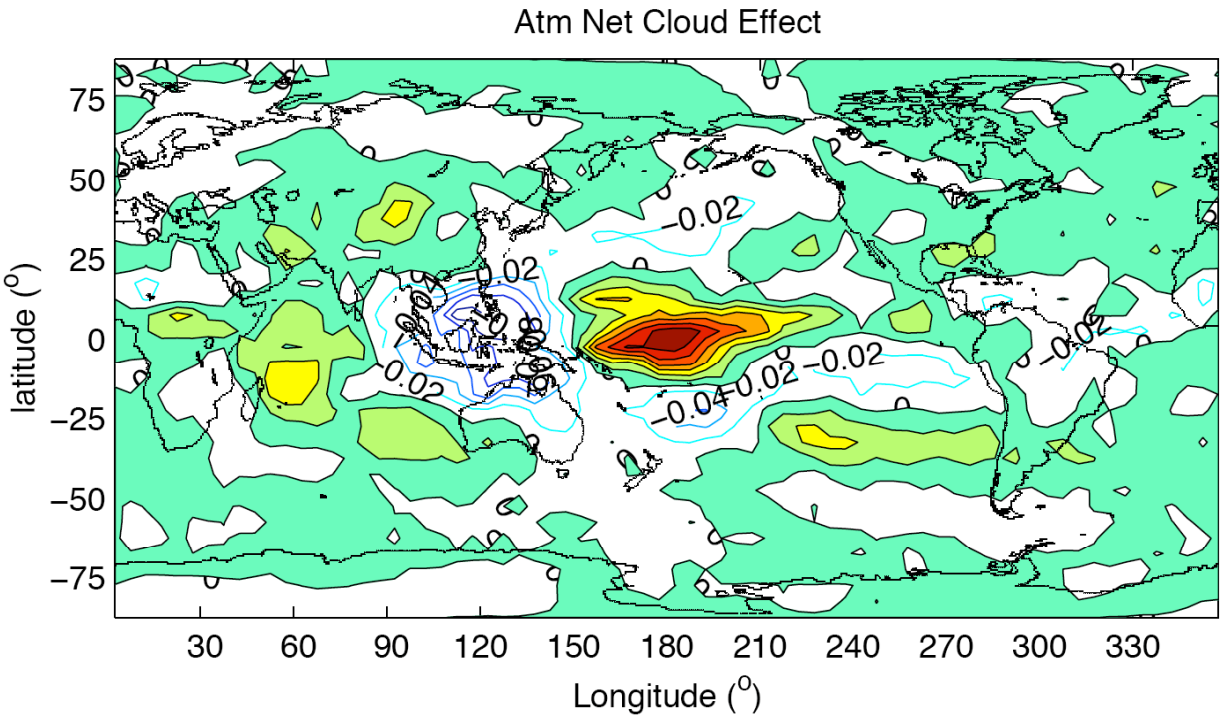


Atm. Cloud Radiative Effect



Positive areas are colored

EOF: 1st component

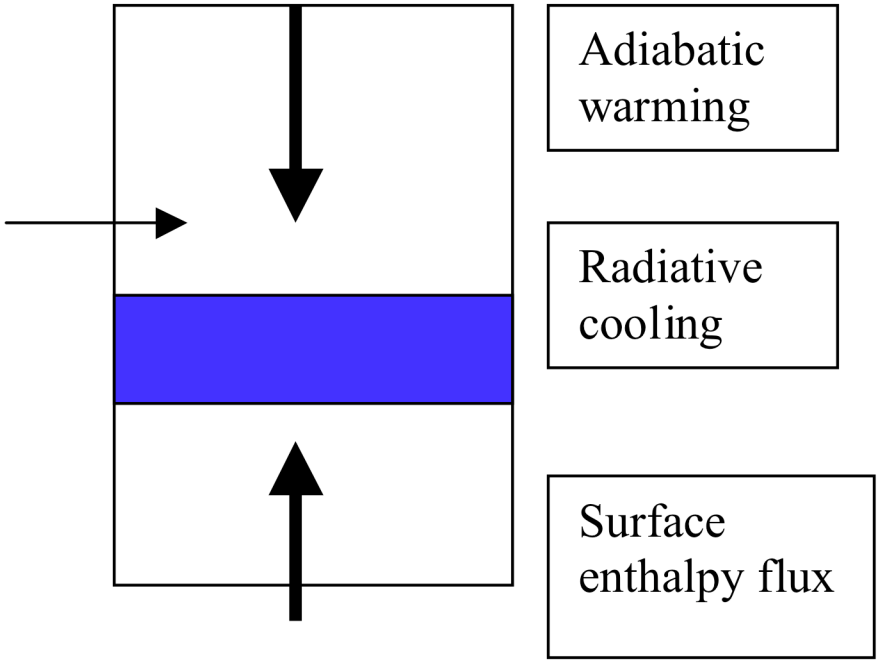


14%

Areas with positive values are colored

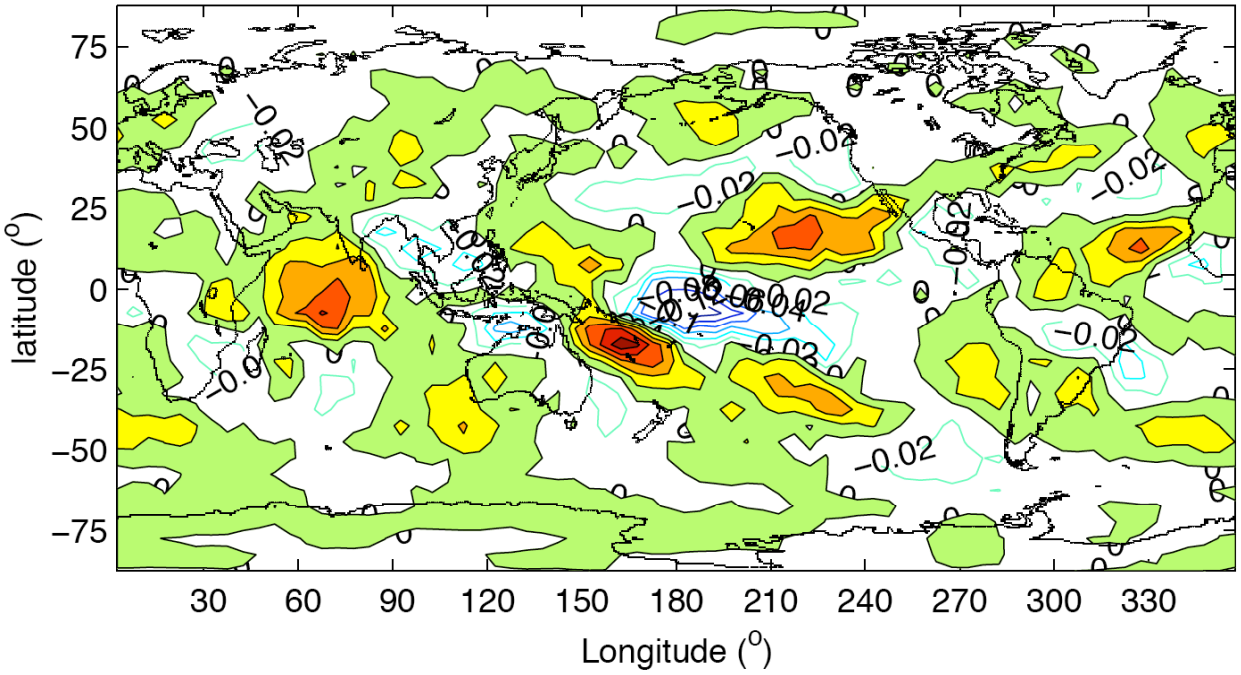
Decreasing high-level clouds in TWP is associated with increasing high-level clouds in central pacific

Atmospheric Energy Budget in the subtropical region



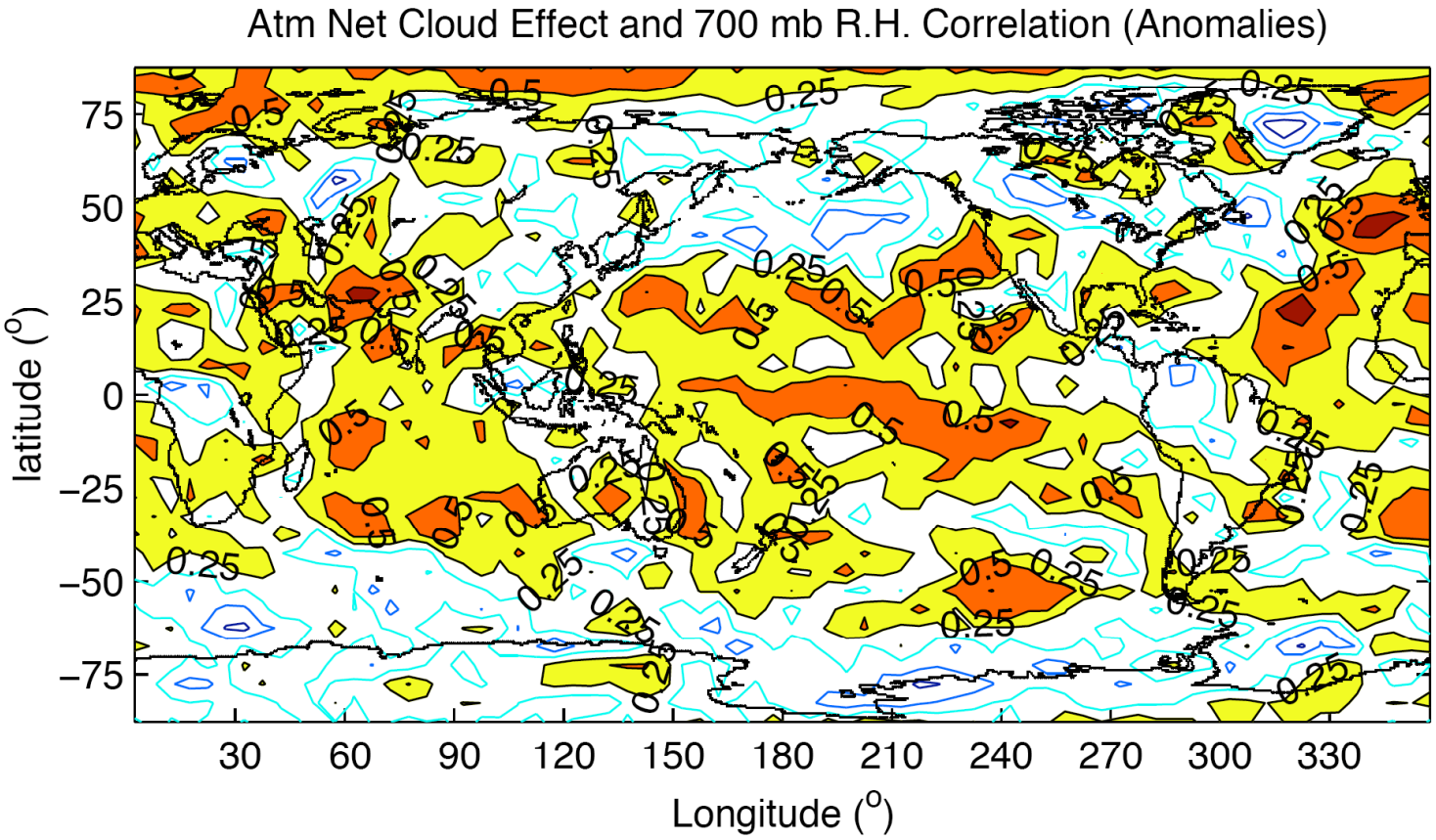
Radiative cooling by low-level clouds needs to be compensated

EOF: 2nd component



7% of variability

700 hP RH vs Atm net Cloud effect



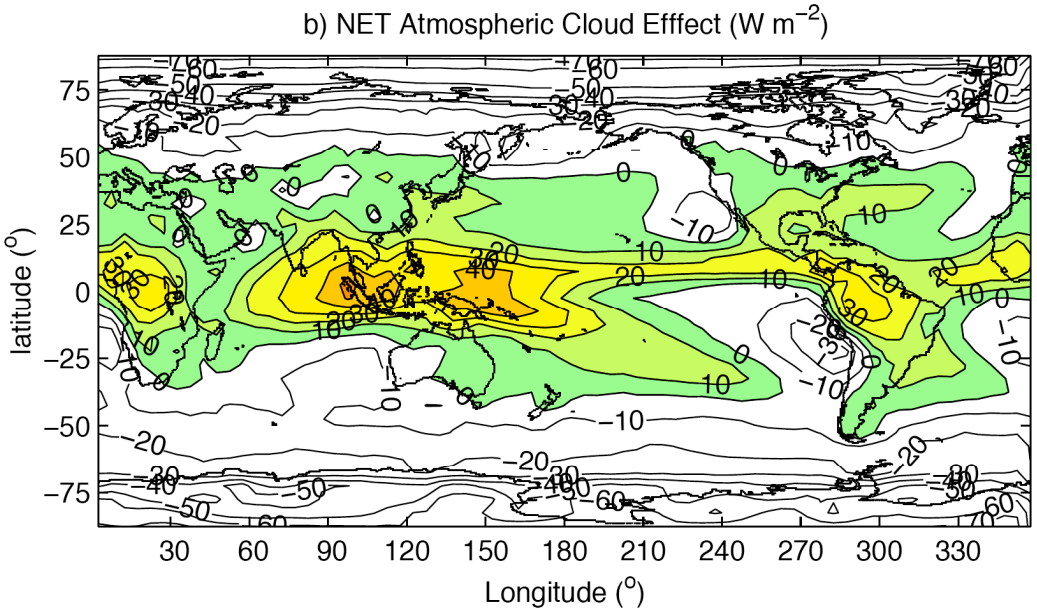
v'>0, RH'>0, positive correlation if high-level clouds increase

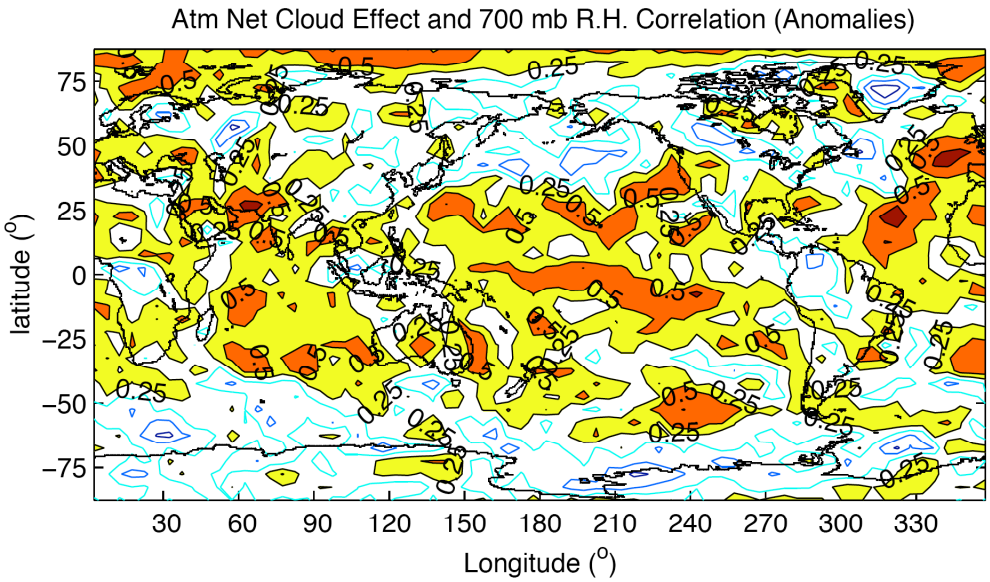
v'<0, RH'<0, positive correlation if low-level clouds decrease

Summary

- Large SW and LW variations occur in western and central pacific.
- Larger variation in SW than LW in subsidence regions in eastern Pacific causes a large variation in the net.
- Clouds are largely responsible for the variability.
- Large variability in the tropics is due to ocean-atmosphere interaction and shift of warm pool of sea water, not heating or cooling by clouds
- Variability averaged over tropics is small because small variation of mean tropical sea surface temperature in the 4-year period. (According to the NOAA Optimum interpolation sea surface temperature, the mean sea surface temperature of tropical pacific ocean is 25.6C and the standard deviation is 0.16C over the 4-year period.)
- The variability in tropical and subtropical regions is appeared to be partially constrained by the variation of tropical sea surface temperature.

Adiabatic warming vs. atmospheric cloud radiative effect

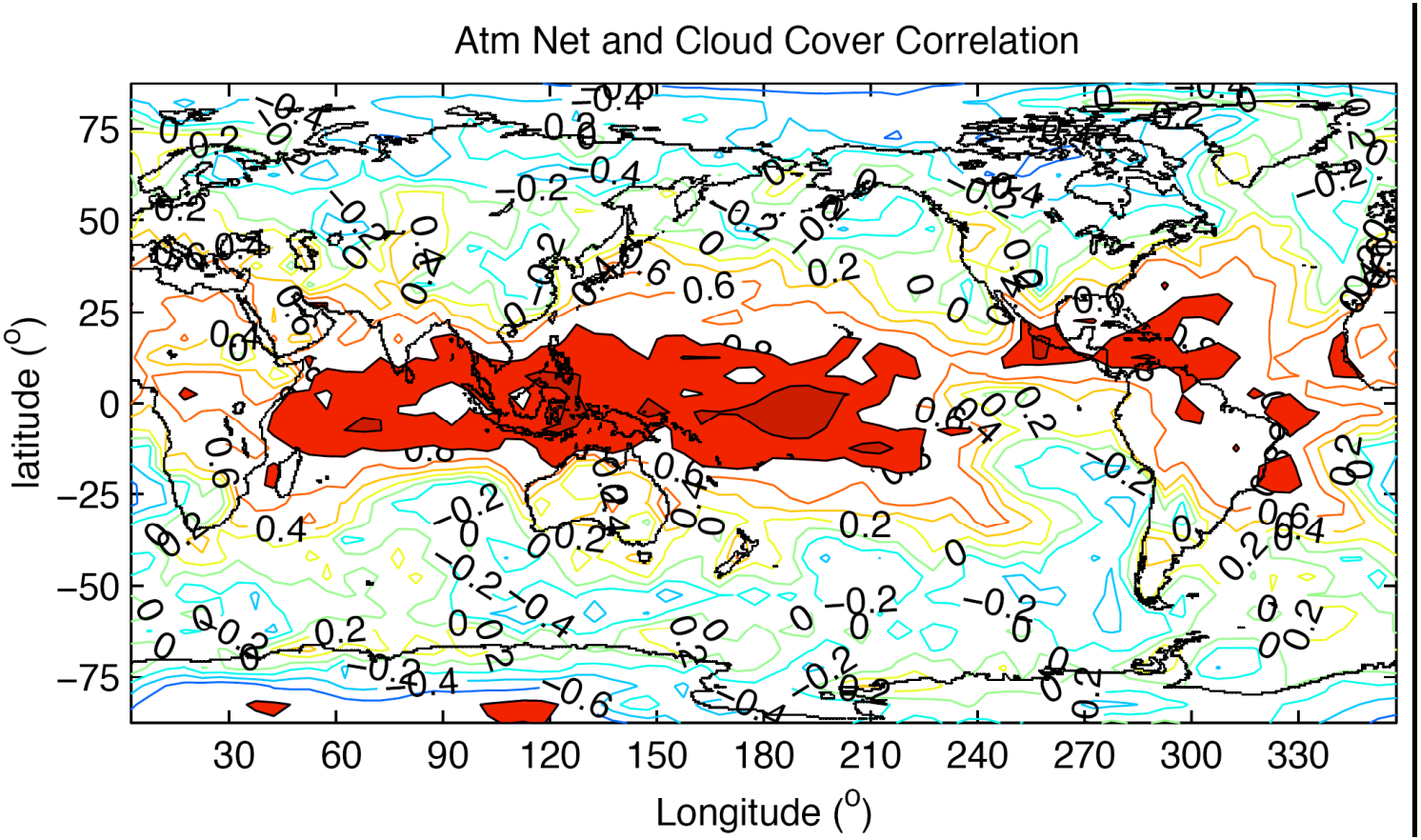




Summary

- The largest TOA SW and LW monthly anomaly standard deviation comes from ENSO
- Large TOA net monthly anomaly standard deviation is caused by low-level clouds and sea ice.
- The variability in tropical and subtropical regions is partially constrained by the variation of mean tropical sea surface temperature. But need more work to show this.

Clouds vs. net atm.



Zonal effect of clouds